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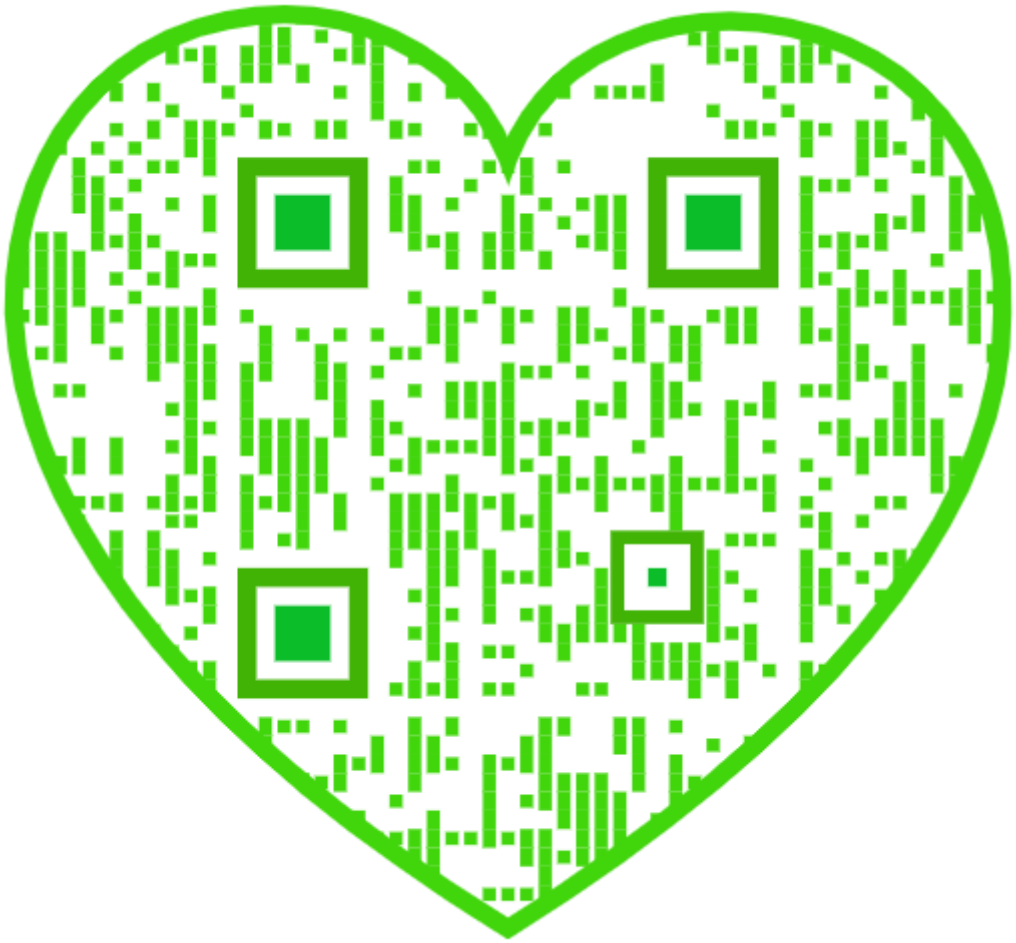

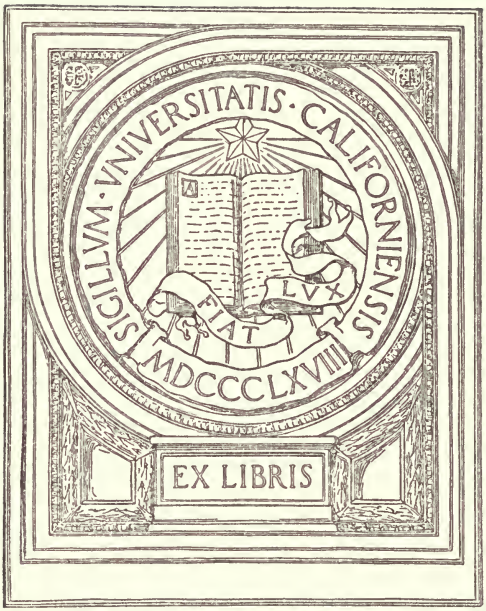
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HISTORY

OF THE

CONFEDERATE POWDER WORKS

HISTORY

OF THE

Confederate Powder Works

BY

COL. (GENERAL) GEO. W. RAINS,

LATE OF THE CONFEDERATE ARMY.

AN ADDRESS DELIVERED BY INVITATION BEFORE THE CONFEDERATE SURVIVORS' ASSOCIATION, AT ITS FOURTH ANNUAL MEETING, ON MEMORIAL DAY, APRIL 26TH, 1882.

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UNIV. OF
CALIFORNIA

ADDRESS.

Fellow Confederate Survivors:

In accepting your invitation to address you on the general history of the Confederate Powder Works, I do so with some hesitation, on account of my close personal connection with a subject which absorbed my thought, time and energies.

In the history of a war we find, generally, but little reference to the manufactories engaged in the preparation of material; they had been previously established, and were in active operation before its commencement, their products being immediately available for active operations. An instance can scarcely be found in modern warfare where previous preparations had not been made, and where the necessary manufacturing works did not already exist.

The late war was entered upon unexpectedly. Throughout the Southern country it was supposed that the North would not seriously oppose a secession of the States from the Federal compact, hence no previous provision had been made for such contingency, and no material of war gathered.

Manufactories existed on a very limited scale, and none for war purposes, hence their speedy erection was of extreme importance, and had to be accomplished under the most unfavorable conditions.

The entire supply of gunpowder in the Confederacy at the beginning of the conflict, was scarcely sufficient for one month of active operations, and not a pound was being made througout its limits. To enter upon a great war without a supply of this essential material, and without effective means of procuring it from abroad, or of manufacturing it at home, was appalling.

No one was so well aware of this condition of things as the President of the Confederate States, who, being an educated soldier, was fully alive to the requirements of war, and at once took active measures for the creation of war material. Among these, was the erection of a great gunpowder manufactory.

It is the custom of the different nations, in addition to the private factories of gunpowder, to have erected at different points national

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works to supply the demand for war. The very limited resources of the Confederacy not admitting of division, had to be accumulated at one point. Mr. Davis was necessarily acquainted with most of the officers of the old army, as he was graduated at West Point, served with great distinction in the war with Mexico, and had been Secretary of War under the Federal Government; he was thus enabled to select his agents for the different services required. Thus that very competent officer, General Gorgas, was placed at the head of the Ordinance Department; I had the honor of being appointed to take charge of the manufactory of gunpowder, a *carte blanche* being given. The necessary works were to be erected as nearly central as practical; to be permanent structures, and of sufficient magnitude to supply the armies in the field and the artillery of the forts and defences.

On the 10th July, 1861, I left Richmond to enter upon this duty. Making a rapid tour through the South to find a suitable site, Augusta was selected, for several reasons: for its central position; for its canal transportation and water-power; for its railroad facilities; and for its security from attack—since the loss of the works would have been followed by disastrous consequences.

The small amount, comparatively, of gunpowder captured with the Navy Yard at Norfolk, with that on hand from other sources, had been distributed to the army gathering on the Potomac, to Richmond, Yorktown, Pensacola, Mobile, New Orleans, and other places; scarcely any being left for the force assembling under the command of General Albert Sidney Johnson, in Kentucky. The Federal forces, having the requisite advantages for equipment and transportation, were assembling in large bodies, and the utmost energy was required to prevent the loss of a battle by failure in ammunition. General Johnson's command was the most urgent in its wants, hence required the first attention.

The State of Tennessee, through the energy of Governor Harris, and its Military Committee consisting of General Harding and Colonel Bailey, had at the earliest moment taken measures to supply his army by making contracts for saltpetre, to be supplied from the limestone caves, and with the Sycamore Powder Mill, not far from Nashville, which was to be enlarged and put into immediate operation. These contracts were turned over to the Confederate Government on my arrival in that city, and every assistance possible given

by the State authorities. Mr. S. D. Morgan, a private citizen of Nashville, but a gentleman of great energy and influence, rendered essential service to the officers of the Confederacy. The Sycamore Stamping Mill was soon put into operation, but its limited arrangements, particularly for preparing the saltpetre, caused the product to be small. Notwithstanding the rapid construction of new stampers, and other parts, it was only in the latter part of September that five hundred pounds of powder daily were produced.

It was soon perceived that to increase the supply, a special refinery for saltpetre would have to be erected; works accordingly were projected, commenced, and mainly completed, at Nashville, by the 9th October, on which day 1,500 lbs. were refined, and this amount was gradually increased to 3,000 lbs. daily. Experts were not to be found, and for some days every part of the operations were carried on under my personal instruction.

Gunpowder contains three-fourths of its weight of saltpetre, and to have its proper and enduring strength, this constituent must be refined to almost chemical purity. Thus the obtaining of this material and its preparation, became matters of the highest consideration.

The Governor of Georgia, at the suggestion of Lieutenant Boggs, late of the Ordinance Department of the old army, had purchased a small cargo of saltpetre and sulphur in Philadelphia, which fortunately arrived safely at Savannah just before that port was blockaded. This store of material, although comparatively small, was of extraordinary value, as from it mainly the gunpowder for General A. S. Johnson's army was supplied, as well as the Batteries at Fort Pillow, Island Number 10, and Memphis, on the Mississippi river.

The earth of the limestone caves of Tennessee, Alabama, Georgia, Arkansas, and other States, was rich in nitrate of lime, and this salt was convertible into saltpetre by lixiviation and saturating with the lye of wood ashes. Some of these caves were personally visited, and great efforts made to have them worked to full capacity. Agents were sent out to investigate their capabilities with authority to make contracts, and supply the necessary information for their working; the last was accomplished by means of a pamphlet which I published in Nashville giving detailed instructions, and which was distributed throughout the country; it was republished in Richmond, New Orleans and other places. As rapidly as the crude saltpetre was re-

ceived from the caves it was refined and sent to the powder mills, and the products mostly sent to General A. S. Johnson's command. About 100,000 pounds of gunpowder were thus supplied before the fall of Nashville, besides a considerable amount sent to New Orleans and other places.

The caves of Arkansas were rich in nitrous earth, and those of Texas still more so, and these supplied the armies west of the Mississippi river with material for gunpowder. As early as practicable I sent out instructed powder-makers to both those States, who under the directions of the military authorities, assisted to put up the necessary powder mills for the Trans-Mississippi department, which after the fall of Nashville was left necessarily to its own resources.

In the early part of November my time had become so much occupied that it was no longer practicable to attend to the production of saltpetre, and Mr. F. H. Smith was sent from Richmond by the Chief of Ordinance to relive me from its duties. At a later day a separate department was established, called the Nitre and Mining Bureau, which then had the entire charge of its production.

In the latter part of November, by the desire of General Lovell—the able officer in command at New Orleans—I proceeded to that city and examined the temporary arrangements for making gunpowder, and also conferred with him relative to procuring a supply of saltpetre from abroad. He suggested the chartering of the steamship Tennessee, then lying idle in the river near the city, to proceed at once to Liverpool and take in a cargo of saltpetre and return to New Orleans, or, in case of necessity, to put in at Charleston or Wilmington. The suggestion met my views, and was approved by Mr. Benjamin, then Secretary of War, but was not carried out on account of the effective blockade of the mouth of the Mississippi.

The Confederate Government, however, by its agents in Europe, purchased saltpetre which was shipped on swift blockade runners which arrived from time to time at Charleston and Wilmington. This proved to be adequate to our wants, and about two millions, seven hundred thousand pounds were thus received during the war and sent to the Confederate Powder Works. The amount obtained from the caves amounted to about three hundred thousand pounds for the same period. Thus the total amount received at the works amounted to about 1,500 tons.

The Governor and Military Committee of Tennessee, in making

the contracts for war material, had engaged Mr. Whiteman, of Nashville, an energetic citizen, to construct a Powder Mill at Manchester, who at my suggestion adopted the incorporating process of heavy rollers on an iron circular bed, such as I had proposed to employ at the Confederate Powder Works erected at Augusta. The construction of this mill was urged on so successfully, that by the middle of October one set of rollers was in operation, and a second set in course of erection; a month later, by supplying saltpetre and charcoal from the refinery at Nashville, 1,500 pounds of gunpowder were daily produced.

I had proposed at an early period to make this Powder Mill a school of instruction for a few selected men, so as to have them ready for service at the Augusta Powder Works when they should commence operations—similaly to what had been done at the Refinery at Nashville, where men were being taught to refine saltpetre and distill charcoal. Before the occupation of Nashville by the Federal forces, these men, together with the machinery and articles of the Refinery in that city, were removed to the Augusta Works; thus they were supplied at the commencement with the necessary means of operation, which could not have been otherwise accomplished. But one man—Wright—could be found in the Southern States who had seen gunpowder made by the incorporating mill—the only kind that can make it of the first quality; he had been a workman at the Waltham Abbey Government Gunpowder Works, in England. He was made available in the operation of the Manchester Mill, and afterwards for a short time at the Augusta Confederate Works, and although sadly defective in a certain way, I was much indebted to his knowledge and experience.

A singular good fortune happened at the commencement of my labors. I came into possession of an invaluable pamphlet by Major Bradley, the Superintendent of the Waltham Abbey Works; in this the entire process and machinery employed at that Factory—the best existing in any country—was succinctly stated; drawings, or working plans, or details of the buildings, or apparatus, however, were not given.

Nowhere could be found a publication in which this was done of any powder factory, hence in the projection of the Confederate Powder Works, I was thrown upon my own resources to supply these deficiences.

During the many hours spent in railroad cars, these matters were thought over and planned separately as necessity required. A rough sketch was made, dimensions given, and location designated; this data was placed in the hands of capable men to carry out. In my young Architect and Civil Engineer, C. Shaler Smith, recommeneded by the proprietors of the Richmond Tredegar Iron Works, I at once recognised genius of a high order, and placed in his hands my rough sketches of buildings to elaborate and give architectural finish. All know with what result, the fine taste exhibited in the massive and beautiful structures which ornamented the banks of the Augusta Canal, for two miles, bore witness of his success.

Good fortune also brought to my notice, by a casual encounter with General Pendelton, Chief of Artillery at Richmond, a skilled machinist, who had served his time at the Tredegar Works, and was then a Sergeant in the Confederate army. He, William Pendleton, was applied for, and in his acquisition, was gained a man of capability and integrity, into whose hands could be confidently placed the erection of all the extensive machinery then in process of construction. The responsible duties of Superintendent of the Works were also committed to his charge.

The Tredegar Iron and Machine Works, at Richmond, were the only ones throughout the South, having adequate capabilities for the construction of the heavy and extensive machinery required in the projected Confederate Powder Works. They were only partially available for the purpose, however, as the demands made upon them for heavy artillery, and for all kinds of urgent work required by the Government, absorbed their resources, nevertheless, I was compelled to call upon them for most of the twelve circular iron beds, and twenty-four ponderous five ton iron rollers, with other work required for the incorporating Mills, which, together, weighed 240 tons; two of the rollers were made in Macon and two in Chattanooga.

The immense iron shaft, nearly three hundred feet long, varying from twelve inches in diameter at the central portions, to ten inches and eight inches, toward the extremities, was cast and completed in sections, mainly, at the Webster Foundry and Machine Works at the latter city; here, also, were made the twelve heavy spur wheels, and twelve powerful friction arrangements to start and stop gradually each set of rollers separately, as the main shaft, working in the

extensive subterranean archway, which extended below the line of mills, continued its incessant revolutions.

The great gear-wheel, sixteen feet in diameter, attached to the centre of this shaft, giving it motion, with its corresponding massive pinion on the engine shaft, were cast and accurately finished at Atlanta.

The fine steam engine of 130-horse power, having two cylinders and a fly wheel of fourteen tons weight, and five boilers was made at the North just before the war, and brought to that city to be used in a flouring mill. This was purchased as being exactly the motive power required.

It was designed to make use of the water power of the canal for all purposes, but its available capacities at that time would not permit this, for the large amount required by the incorporating mills; it was employed at the other and more dangerous buildings, which required a smaller amount of power. Two smaller steam engines—one procured at Macon and the other at Selma—were employed in the Refining building. Two Hydraulic Presses were procured at Richmond; the twelve iron evaporating pans, each holding five hundred gallons, were cast at the large Iron Works on the Cumberland River, in Tennessee. The extensive copper drying pans for the powdered saltpetre, being together forty feet long by nine feet broad, were made at Nashville; the four cast iron Retorts, four feet long by three feet in diameter, with eight cast iron coolers, and twelve sheet iron slip cylinders of nearly the same dimensions, were made at the Augusta Confederate Foundry and Machine Works, where also all the smaller machinery required was constructed. Copper boilers were procured from Wilmington, N. C., being made of large turpentine stills; pumps, pipe and cement from Charleston; sheet copper from Savannah and Nashville; tin and zinc for roofing from Mobile; the larger steam pipes from Hight's Foundry, in Augusta, and the smaller from New Orleans; iron and coal for castings were had from North Georgia and Alabama, and copper from Ducktown, in Tennessee.

Thus material was gathered from all the Southern States to unite with the resources of the City of Augusta, to construct the largest and finest Gunpowder Factory to be found in any country.

On the 20th of July, 1861, I examined the Augusta Canal and resources of the city, and later selected the location of the Powder

Works, beginning at the site of the United States old Magazine, half a mile from the western city limit. Land adjacent was purchased, and also that between the canal and the river for a distance of two miles, so that the different buildings required, might be seperated by intervals of at least one thousand feet for safety in case any one of them should have an explosion.

It was remarkable that the most favorable conditions required in the erection of an extensive Powder manufactory, were all met at this location, and nowhere eise attainable. These are:

1. A central point of the country, for obvious reasons.

2. On a main line of railroad communication, to distribute the products to all parts of the country.

3. On a canal or river, which could afford a safe and economical means of transportation of the pulverized materials in process of manufacture, at the same time affording the necessary water-power to the different buildings.

4. In the neighborhood of a town or city, from which mechanics and employes, as well as necessary articles, could be obtained.

5. A location near which the best building materials could be procured for permanent structures.

6. A temperate climate, where operations could be continued throughout the year without obstructions from ice, and to avoid the hazard and expense of warming the building.

7. A district of country free from lime and earthy salts, so that the large amount of water required in the operations of the Saltpetre Refinery should be as nearly pure as possible.

8. A location which would insure an abundant and cheap supply of the proper kind of wood required in the making of gunpowder.

9. A situation which, whilst sufficiently near a town to procure readily supplies and workmen, should, at the same time, be removed so far off that the dangerous structures, should an explosion occur, would cause no damage to the nearest inhabitant.

10. Hence, also, the canal or stream on which the works exist, should have but little traffic or commerce, and, in the vicinity of the works, should pass through a sparsley inhabited district.

The Augusta Canal, having been selected for the site of the Confederate Powder Works, contracts were immediately entered into for the brick, stone and carpenter's work, on very favorable terms.

At the beginning of the war, business was more or less paralyzed,

so that the manufacturers and builders were, to a considerable extent, thrown out of employment, which enabled contracts to be made advantageously at the usual prices. Thus, the total cost of the entire works did not exceed three hundred and eighty-five thousand dollars.

The erection of these works on the ground of economy alone, was of great service to the Confederate Government. The extreme hazard of importing gunpowder through the blockade, raised its average price, the first year of the war, to three dollars per pound. There were made one million pounds at the works in that period, at a total cost, including the materials, of one million and eighty thousand dollars; thus saving to the Government in one year, one million, nine hundred and twenty thousand dollars.

The requisite land having been purchased, and contracts made for building materials, the site of the main buildings were located by myself, and construction commenced on the 13th of September, 1861, under the immediate supervision of Mr. —— Grant, a young civil engineer from Savannah. These buildings were erected of the excellent bricks supplied by the Augusta and Hamburg yards, which were worked to their full capacity, and above five millions were supplied. The handsome granite of Stone Mountain, on the Georgia Railroad, was employed for the sills, lintels, copings, and foundation stones. The whole of the buildings were erected by Messrs. Denning and Bowe, of Augusta, the former having immediate charge, and could not be surpassed for excellence of workmanship.

The first structure—or the one nearest the city—was called the Refinery building, because the central portion was used for such purposes, but it included a saltpetre and sulphur warehouse, of a capacity of fifteen hundred tons, on the east end, and a charcoal department and machine shop with a steam engine on the west end. Rifle and ballistic pendulums on the northeast, and the steam boiler house on the northwest portions. There were four square towers at the corners, used as offices; the entire structure forming three sides of a square, fronting two hundred and fifty feet along the canal, and extending back two hundred and seventy-five feet. The north side was mostly a brick enclosure with high walls, but having no roof, and temporority used for storing wood—its ultimate destination was for worshops.

Within the square were located the kilns for drying the wood to

be distilled in the charcoal retorts; the copper boilers and other apparatus for the extraction of the saltpetre from damaged powder; as also the arrangement for the final extraction of the saltpetre from the refuse of the Refinery; lastly, the great chimney, into which all the smoke flues of the entire structure terminated.

In the projection of this part of the Powder Works, I conceived the design of making the central portion present the appearance of a grand monumental structure. For this purpose the chimney was placed centrally, and its exterior dimensions considerably enlarged; in fact, it is composed of two distinct parts, the chimney and outside obelisk; the former being enclosed at its base by a square tower, nineteen by thirty-five feet in height, whose battlements arose to view above the front walls. From the top of this tower the enveloping obelisk commenced, and ascended one hundred and fifteen feet, making the complete structure one hundred and fifty feet from the ground to the coping. The interior chimney flue is five feet square from bottom to top. The corner stone, or rather the box, containing the usual documents, was, by a fancy of the architect, placed in one of the corners of the top coping of the obelisk.

The saltpetre refinery occupied the right central portion of the front, being sixty-five feet long, fifty-five feet broad and thirty feet high, open from the floor to the ventilated roof. At the east end were four of the large evaporating iron pans, placed side by side, and elevated three feet above the floor by the brick work which surrounded them; five similar pans were in a corresponding position at the west end, and the large copper drying pans occupied forty feet along the north side at the same height. Each evaporating pan had a separate furnace, and the heated air from the whole passed beneath, and in contact with the bottoms of the drying pans on its way to the great chimney; the furnaces opened into side rooms communicating with the outside open space in the rear of the building. Thus the refining room was entirely free from ashes, dust and smoke.

The centre space of the floor, about thirty-six feet square, was sunk four feet to allow water from the canal to pass around the bottoms of two of the large evaporating pans, which were placed therein near the centre of this area, and nine feet apart; these were used for a special purpose.

The best quality of gunpowder can only be made from the purest

saltpetre; the impurities of the crude material are mainly deliquescent salts, which rapidly deteriorate the strength of the powder by the moisture absorbed. To refine more or less the rough saltpetre of commerce is then a necessity even in producing an inferior article.

To carry the refining process to the extent of nearly absolute purity, required several successive crystallizations and washings, involving a large amount of manual labor in the manipulation, and consuming much time. This was particularly the case in the very large amount of saltpetre, eight to ten thousand pounds per day, used by the Works, the refining of which would demand extended buildings and apparatus, as well as requiring a large number of operatives. Hence, it became desirable to devise methods by which hand labor could be superseded by motive power and machinery; in this I was entirely successful. Thus, in the operations of filling the various boiling pans with water or mother-liquor; the transference of the boiling solution of saltpetre to the draining trough, and thence to the crystallizing machines; the cooling down of the solutions, and their constant agitation to break up the forming crystals into fine particles, and transferring of these to an adjoining tank; the washing of the crystallized mass, and the subsequent removal of the mother-liquor and wash- waters, were all accomplished by machinery, with the assistance of two or three workmen only.

The saving of time and labor was thus manifest, and the rapidity with which these operations were performed, permitted a double and triple process in a single day; thus allowing a degree of purity in the product of refined saltpetre not attained in any other refinery. Its purity was such generally, that there was not the one-hundred-thousandth part of chlorides left in the salt.

Of the machinery used, the most important was a bronze revolving wheel with buckets attached to the periphery, which worked into an iron pan or kettle, whose section was an arc of a circle; the buckets grazed the surface of the bottom and sides of this kettle, the bottom of the latter being immersed in a current of cold water. The hot filtered solution of the crude saltpetre was received into this kettle, and thus kept into a state of rapid agitation, the effect being to produce a wet mass of minute crystals, which, as fast as formed, were taken up by the sharp edged buckets, and lifted sufficiently high to pour into a receiving vat; this permitted the liquid part to flow back

into the kettle. By this means in a short time the entire mass of fine deposited crystals from the rapidly cooled liquid, were removed to the vat. When the operation was completed the remaining liquid in the kettle was by the revolutions of the bronze wheel, discharged into one of the eight capacious cisterns below the floor; there were two of these machines employed.

The facility for work which this apparatus, with the other mechanical appliances afforded, enabled the refinery to carry the purification of the saltpetre beyond that of the most celebrated powder factories.

Adjoining this part of the Works was the Sulphur Refinery, where this material was prepared from the crude stock, and made ready for the incorporating process. About one hundred and thirty tons of very impure sulphur had been received from Louisana, for the use of the Powder Works; it had been purchased before the war by the planters for use in the making of sugar, and was bought up by the Confederate officers. The best quality of gunpowder has its sulphur chemically pure, which could be demonstrated by showing no trace of acid when powdered and boiled in water, and should entirely evaporate on a piece of glass when heated, leaving no stain. This can only be accomplished practically by distillation. The crude article was melted and poured into upright, thick wooden boxes five feet high and ten inches square at the bottom, tapering upwards; when cold the earthy matters would be found in the lower portion by subsidence, leaving about three feet apparently pure. This was broken off and placed into two kettles of suitable form and dimensions, having furnaces; the tops of these kettles were connected by a bent iron pipe to an enlarged portion, which was surrounded with water. On the application of heat the sulphur vaporized, and passing over through the pipe was condensed in the cooled portion, whence it trickled in a thick stream into a receiving vessel below; the first portions being rejected, the remainder was of a beautiful citron yellow when cold, and entirely pure.

Unlike the refined saltpetre, the purified sulphur had to be pulverized and bolted like flour before being used. The former was done by two iron wheels of twelve inches face and five feet diameter, weighing six hundred pounds each, revolving on a bed circle of iron like the incorporating rollers; the later was accomplished by bolters, but when these were worn out and could not be replaced, for want

of the silk cloth, which was not to be found in the South, necessity compelled me to devise a different, and as it proved, a superior method.

The pulverized sulphur was placed in barrels or cylinders, with hollow axles, which were made to revolve slowly by machinery; there were ledges on the interior which caused the sulphur to be lifted and poured over as the cylinders revolved; a light current of air was blown through each, entering the hollow axle at one end, and passing out through the axle at the other end, which led into an adjoining room; there the impalpable sulphur dust was deposited, much finer than by the usual bolting process.

Adjoining this Refinery was the department in which charcoal was made and pulverized. Charcoal for gunpowder has to be made of a porous fine-grained wood, having very little ashes when burned; willow is generally preferred, and was used at first in the Powder Works, but the exigencies of the war taking away those who would ordinarily have supplied it, rendered it impracticable to procure a sufficient quantity. Recourse was had to the cotton wood, which was abundant; on trial its charcoal was found fully equal to that of the willow for the purpose, and was, thereafter always used.

Charcoal for gunpowder must be made by what is termed the distilling process; that is, the wood must be heated in iron retorts to the proper degree, to have it of the best quality and free from sand or grit. For this purpose cast iron cylinders, or retorts, six feet long and four feet in diameter were used, placed over furnaces, each having one end solid and the other with a movable cover; into these were run the slip cylinders, which contained the kiln dried cotton wood, split up into sticks about one and a half inches in diameter, and entirely filling it.

The slip cylinders were charged with the wood in an outside apartment, their covers put on, then readily moved by cranes to the retorts, into which they were pushed; the covers of which were then luted with clay and closely applied. The bottoms of the retorts being perforated, permitted the escape of the vapors and gases into the furnaces beneath, where inflaming, they supplied mainly the heat required in the operation. In about two hours the slip cylinders were withdrawn from the retorts and moved by the cranes over, and lowered into the cast iron coolers beneath the floor; these had water from the canal circulating around them; the covers being then put

on to exclude the air, the mass of charcoal was rapidly cooled. As soon as a slip cylinder was removed from a retort a freshly charged one would take its place, and thus the process was continued. The slip cylinders were taken out of the coolers in succession by the cranes, and swung over a long and broad table upon which their contents were dropped; here the sticks of charcoal were separately examined and the imperfect rejected. The charcoal was then placed in pulverizing barrels with bronze balls, which revolving by machinery, soon reduced it more or less to a fine powder; it was then bolted, and with the sulphur and saltpetre taken to the weighing house. Here the three materials were arranged into sixty pounds charges, by mingling forty-five pounds of saltpetre, nine pounds of charcoal and six pounds of sulphur, which was then moistened and ready for incorporation.

Reflecting over the processes for making gunpowder, it suggested itself that the chemical reactions would necessarily have the most favorable conditions, when there should be the most intimate approximation of the component molecules. That, as the charcoal by its combustion with the oxygen of the saltpetre, supplied the expanded gases which produced the explosive force, it was of the first consideration that there should be the most perfect mixture practicable between these two ingredients. Under the microscope a fine particle of charcoal was seen to be a mass of carbon penetrated by numerous pores, hence it became necessary to completely fill these minute pores with the saltpetre to have the best condition. This might be accomplished by the usual processes, as the charge is kept moistened when stamped or rolled, but as it will not answer to have the mass *wet* during the incorporating operation, only moist or damp, the completion of the process was necessarily delayed. If this mass of material could be made into a semi-liquid condition by the action of steam, the hot solution of saltpetre would speedily penetrate the minute pores of the charcoal, and thus the desired end would be rapidly attained.

Accordingly, the following process was devised: The moistened sixty pounds charges, roughly mixed and moistened with water, were introduced into horizontal cylinders of sheet copper thirty inches long by eighteen inches in diameter. These cylinders revolved slowly on a common axis, consisting of a heavy brass tube three inches in diameter, perforated with holes. High pressure

steam was introduced through the tube raising the temperature to the boiling point while the water produced by condensation, added to that originally used to moisten the materials, reduced them to a semi-liquid slush, which was run out of the cylinders after about eight minutes rotation. On cooling, this mud became a damp solid cake, the saltpetre which in the state of boiling hot saturated solution had entered the minutest pores of the charcoal, now crystalizing. The cake as produced was transferred to the incorporating mills, and under the five ton rollers was in an hour brought to the condition of finished mill cake, ready to be cooled and granulated, while without the steaming process, four hours incorporation in the mills had previously been necessary to produce powder of the same first-class character. The capacity of the work of the mills was thus practically quadrupled, the thorough saturation of the charcoal with saltpetre being accomplished by the steaming, while it remained for the rollers merely to complete the incorporation of the whole mass and give the required density to the mill cake.

The Incorporating Mills, twelve in number, extended along the canal beyond the Refinery building and further back from its bank, having the Laboratory between the two; they were two hundred and ninety-six feet long. This seperation was for safety, as they worked explosive material. The walls were massive, being four to ten feet thick, the horizontal section of each being that of a huge mortar of seventeen feet wide by twenty-four feet long; the height of the walls was twenty-eight feet; they faced alternately in opposite directions, so that an explosion of one would not be communicated to those adjoining.

The fronts were constructed of light wood and glass, and the roofs of sheet zinc, so that but slight resistance would be offered, upwards and outwards, to the explosive force. A wing wall, nearly as high as the main walls, and three feet thick, extended outwards from the centre of the exterior back wall of each mill twenty feet, to guard still further against the effects of an explosion. Behind these the powder-makers stood, for safety, while starting or stopping the motion of the ponderous rollers. This was done by means of a long lever, which threw in or out of gear the friction arrangement, which worked each set beneath the floor, in the thick archway which extended from end to end beneath the mills. It has already been stated that this archway contained the great iron shaft

which imparted motion to all the mills, and which derived its own from the large steam engine, which was located above, in the centre apartments seperating the mills into two divisions.

In adddition to the above precautions to prevent the explosion of a mill from extending to the others, above each set of rollers was balanced a vessel containing about thirty gallons of water. This was connected by means of a small iron shaft with a similar vessel to each mill of the division. Thus, on an explosion in one mill, its bed-plate was instantly drenched with water, and this caused the same to take place at the same moment with all the others.

These precautions were rendered the more necessary by the carelessness of the powder-makers, who might not remove the broke up powder cake from the mill enclosure before placing a new charge under the rollers, thus having one hundred and twenty pounds of material to take fire at the same time—as once happened—producing a powerful explosion. There occurred only three explosions at these mills—all before the steaming process was adopted—and in the first only was any one injured. In that one no material harm was done, as the two powder-makers—exposed by their own carelessness—were at work again in a few days. This explosion completely destroyed the slight roof, as well as the wood and glass front, but did scarcely any other damage to the mill, and had no action on the other mills further than drenching their beds with water. The other two explosions were insignificant.

These incorporating mills consisted, each, of an iron circular flat bed of seven feet diameter, fixed in a mass of masonry built up above the brick archway, through the center of the floor, to a convenient height. On this bed two massive iron rollers, six feet in diameter and fifteen inches face, revolved. Each weighed five tons. They had a common axle of wrought iron, of five inches diameter, and a vertical shaft of cast iron passing through the centre of the bed, having a rectangular cross-head through which the axle worked. This shaft connected below with the machinery which gave it motion from the main shaft.

These rollers were not equi-distant from the centre of revolution, by which arrangement evry part of the charge of materials on the bed was subjected to their action—which was crushing, grinding, mixing and compressing; grinding and mixing from the twisting motion which followed from so large a diameter revolving in so

small a circle, and crushing and compressing from the weight of the rollers.

To keep the powder on the bed, a wooden curb, funnel-shapped, two feet, high was placed around the circumference, fitting closely, extending outwards at an angle of forty-five degrees. In the centre of the bed was a short cylinder of metal, two feet in diamenter and six inches high, through the top of which the vertical shaft passed. This prevented the powder working inwards. It also acted as a steam-chamber to keep the bed-plate warm; but this was not used for the purpose, since the steaming process rendered it unnecessary. A scraper, or plow, followed each roller, which continually broke up the powder-cake, mixed its fragments, and kept them in the path of the rollers.

At the commencement of the operation the charge of sixty pounds of steamed materials was uniformly distributed over the bed; the rollers were then set into motion, revolving about ten times each minute, which continued for an hour; the broken up powder, or mill cake, which was about five-eights of an inch thick, was then removed from the bed, having a blackish grey color and taken to the cooling magazines. These were excavated in the clay and rock on the other side of the canal, about one hundred yards distant; were four in number and separated from each other; here the mill cake became cold and hard, and was ready for the next operation, that of granulation..

The permanent building in which this was done was about fifteen hundred feet distant from the Powder Mills, on the same side, further up the canal; this, as well as each of the other permanent structures, was made of brick, having thin walls and light roofs. Wood in the damp atmosphere of the canal speedily decayed.

A natural growth of trees and brush-wood intervened between the buildings along the canal, which were generally situated about one thousand feet apart; thus the explosion of any one of them would be harmless to the remainder. There was a temporary structure of wood used at first for granulation, about one hundred yards distant from the permanent building, on the opposite side of the canal; this, after a use of some months, exploded with about three tons of gunpowder.

The explosion was heavy, shaking the earth for some distance, and throwing up a convolving column of flame and white smoke

five hundred feet in height. It was composed of a series of confused masses of smoke and heated air revolving in vertical planes with extraordinary velocity, through which the flames flashed outwards in all directions; this was followed by the thundering sound of the explosion, which vibrated the air for a mile around, and was heard within the limits of the city.

There were seven men within the structure, a sentinel outside, and a boy with a mule in a shed adjoining. The bodies of the seven men and the boy,with the debris, were carried up with the ascending column, and by its revolving action, reduced mainly to small fragments and dispersed; the sentinel was killed by the shock, but his body was not otherwise disturbed. A growth of small pines surrounded the place, which effectually intercepted the lateral flying fragments; in fact the force of the explosion did not extend outside a diameter of one hundred feet, but within that area the trees were destroyed and the space where the structure stood was ploughed up and nothing remained. At the time there was no work being done, as the workmen were awaiting the arrival of the boat with the mill cake. The careful foreman, Gibson, had been called away, and probably the accident happened from matches falling on the floor, as it had been found impossible to prevent their use by the workmen, for smoking, when off duty. This was the only explosion at the Works during the war, except the three at the Mills, already mentioned. It demonstrated the safety of the arrangements, since their was no damage to any portion of the Works except the destruction of the glass sashes, and a slight movement of the roof of the permanent granulating building, about one hundred yards distant. This was about to be occupied, having been completed.

In the granulating building the cold mill cake was broken up into fragments by bronze toothed cylinders of small diameter, and then by smooth ones; these worked in pairs, and successively, in connection with vilratory screens and sieving, all in one machine. By the action of this arrangement the powder cake was broken into fragments, separated into different sizes of grain, and each delivered into its proper receptacle. A very large grained powder, each grain being a cube of one inch in dimensions, and weighing about one ounce, was made by a seperate manipulation of the powder cake, and used for the very largest guns only.

From the granulating building the powder was taken to the dry-

ing, dusting and glazing department, 2500 feet further up the canal. There was an intermediate building designed and used for several months, as the dusting and glazing department, the drying alone being done in the one above mentioned; afterwards the three processes were carried on together in one structure. It was soon perceived that the drying process, which was done by similar arrangements to those used at the government works at Waltham Abbey, England, that is, by placing the powder in small quantities in shallow trays in a frame work, over steam heated pipes, required considerable manual labor and occupied much time. It occurred to me that the same could be accomplished more speedily and with far less, labor, by a single operation, which would likewise perform the glazing and dusting.

To accomplish this the powder from the granulating house was placed in revolving cylinders having hollow axles, and a current of air warmed by passing through an arrangement of steam pipes was blown through, carrying the dust into its receptacle, leaving the grains clear. This also dried and glazed them at the same time. Thus by one operation, by machinery, all three processes were accomplished, resulting in a large saving of labor and time. In addition, a beautiful jet black glazing was given by admitting a small quantity of steam at the proper time to the current of air, while the barrels revolved. This was not generally done, however, as it was regarded of but slight, if any, practical value, the usual glazing answering all required purposes.

Two hundred yards from this department was the boiler house supplying the steam required for the pipes used in the drying process. Its chimney was one hundred yards still further removed, communicating with the furnace by a subteranean arched flue; thus sparks would have had to drift over three hundred yards to reach the clean metal roof of the drying building.

The finished gunpowder was taken to the next building, one thousand five hundred feet beyond, up the canal, where it was weighed out and put into strong wood boxes about two and a half feet long, by one foot square, having the ends let into grooves; one of the ends had a strong wood screw, two inches diameter, with an octagonal head. Experience proved that these powder boxes, a devise of my own from necessity, were superior to barrels, being stronger, occupying less room, standing transportation better, and

safer in use. No explosion ever occurred in their transportation, notwithstanding the occasional Railroad accidents, and the many thousands that were sent from the Powder Works during the war.

The powder boxes being filled, were then transported to the magazine, three quarters of a mile still further up the canal. This wood structure was on a rising ground one hundred yards from the canal, enclosed by a high fence. Its capacity was about one hundred tons of gunpowder.

At this, and every other separate building of the Powder Works, a sentinel was stationed day and night, and the utmost viglance used. Also, each of the seperate buildings along the canal, except the magazine, containing large amounts of gunpowder, were enclosed with high brick walls, having a single entrance.

At the Waltham Abbey Works, in England, the gunpowder cake after being crushed, is subjected to compression by the hydraulic press to give it sufficient density. I found that by using five ton rollers, the proper compression could be given in the powder mills during the incorporation, thus saving much labor and time. The hydraulic press, consequently was only used to compress the powder dust into thin cakes, which were sent to the granulating department to be used for fine grain powder only.

The press house was located between the Cooling Magazines and the granulating building on the same side of the canal as the former. It was a large brick structure provided with two hydraulic presses, cranes, and other appliances, with a turbine water wheel to supply the required motive power. After the discovery that the proper density could be better given to the powder cake, by using sufficiently heavy rollers during the incorporation, this department was used only for the purpose above stated.

The interval of ninety feet between the Refinery building and the Incorporating Mills, was mainly occupied by a fine building called the Laboratory. It had a projecting tower in the front centre, twenty-five feet square at the lower stories, which together were forty-five feet in elevation. From this the upper portion fifteen feet square ascended to the height of thirty feet, making seventy-five feet in all. The upper part of this constituted the clock tower with its four large circular openings for dials. These could be seen for a long distance.

This building which was very striking in its appearance, was

never completed in its interior, as the different work to be here performed was being done at the Arsenal sufficiently well, in temporary structures. Awaiting the completion of the clock, the time was struck by hand, every half hour on the large bell suspended temporarily, in the open building in rear of the Refinery.

The continual testing of the powder, as it was being manufactured to insure its equality in strength, and to ascertain its exact propelling force, was done for the fine graded powders, by excellent musket and ballistic pendulems constructed at the Confederate Machine Works in Augusta under my direction. For the cannon or large grain powders, by the initial velocities given to the proper projectiles in an eight inch Columbiad. To determine these velocities an accurately made electro-ballistic machine, such as was employed at the West Point Military Academy, was constructed at the same works. Also Rodman's apparatus for determining the absolute pressure on each square inch of the bore of the gun, exerted by the charge. In addition to these instruments, complete arrangements for determining the gravimetric densities and hygrometric properties of different samples of gunpowder were made.

The foregoing appliances enabled accurate comparisons to be made at all points between different gunpowders, and to determine the various matters required in the manufacture of the first quality for the various arms of service. That this was successfully done was certified to by Boards of Artillery and Infantry Officers; after the war the captured powder of these works was used in the School of Artillery practice at Fort Monroe, on account of its superiority.
then in active operation, and in his recent valuable book, speaks in

Mr. Davis, whilst President of the Confederacy, visited the works, more than one place in flattering terms of their products. Articles published in the London Times were highly commendatory of the Works and their results, which were copied in Continental papers. They were visited by many distinguished civil and military gentlemen, both native and foreign.

The great extent of the Powder Works and their immense capabilities, were the admiration of all visitors. This was mainly due to the foresight of the President of the Confederacy, who, comprehending the requirements of a great war, then scarcely commenced, strongly drew my attention to the probable necessity of very large supplies of gunpowder to meet the service of artillery of great

calibre, which would probably be employed, as well as the largely increased quantities necessary to meet the rapid firing of the improved small arms, with which infantry and calvary were now supplied.

The daily product of the Works varied with the demand for gunpowder, and with the amount of saltpetre on hand. At no time after their completion were they worked to their full capacity; indeed, were only worked during daylight. Even when supplying the urgent call of General Ripley at Charleston for cannon powder, to replace the twenty-two thousand pounds consumed during the action with the iron-clad fleet; two days' work nearly supplied that amount.

Notwithstanding the admirable serving of the heavy artillery at Fort Sumter during that engagement, it would have fallen and Charleston captured, had any but the strongest gunpowder been used. The armor of the iron-clads, though constructed expressly to withstand the heaviest charges and projectiles, gave way before its propelling force. Mr. Davis makes the statement that the engagement between the Alabama and Kearsarge would have resulted in a victory for the former, had Admiral Semmes been supplied with the powder from these works. Any failure in their construction and products would have rested with myself. A carte blanche had been given, and there was no one to share the appalling responsibility.

There were made at the Confederate Powder Works at Augusta, commencing April 10, 1862, and terminating April 18, 1865, 2, 750,000 pounds, or one thousand, three hundred and seventy-five tons of gunpowder. This was distributed throughout the Confederacy, mostly east of the Mississippi river. There remained on hand, at the Magazine, at the end of operations, about seventy thousand pounds, besides considerable amounts of saltpetre and other material.

The Navy Department during the war established a manufactory of gunpowder at Petersburg, Virginia, which was afterwards removed to Charlotte, North Carolina, and then to Columbia, South Carolina. A powder mill was put into operation at Richmond, Virginia, also, at Raleigh, North Carolina, but the extent of their operations is unknown. Two small stamping mills in the northwestern portion of South Carolina, near the mountains, which were erected to make blasting powder for the neighboring tunnel, were

visited, but I found that they could be made available only to a very limited extent.

The Confederate Powder Works were so constructed that the rough materials were received at the building nearest the city; thence successively passed up the canal from building to building in the progressive stages of manufacture, until it arrived finished and ready for shipping at the Magazine.

To facilitate the transportation, a short branch of railroad was constructed connecting the canal basin with the Georgia Railroad. The safe, economical, and ready means of transportation by the canal were invaluable; no accident ever happened, notwithstanding the immense amount of combustible material—over two thousand five hundred tons—which had passed to and fro over it during the three years of operations. From the canal bank to the entrance of each building, the walks were covered with compressed sawdust, and rubber shoes were worn by all operatives in the departments containing gunpowder.

It is an interesting fact that Augusta was the only city of note in the South, which was not occupied at some time by the Federal forces during the war; here the flag of the Confederacy floated undisturbed to the end.

The extensive Sibley Cotton Factory has been erected on a portion of the site of the Refinery, Laboratory and Incorporating Mills, and so arranged that the Confederate obelisk stands conspicuously in front of the centre; the battlemented and ornamental architecture of the Powder Works was adopted in the construction of the Factory buildings, which give them a fine and noble appearance.

Here was once heard the noise of the clanking wheels and muffled sounds of the ponderous rollers of war, as they slowly concentrated into black masses the enormous energies which were to shake the earth and air, with the roar and deafening explosions of the battle field. Now the air is again filled with the sounds of moving machinery, but it is the busy hum of peaceful occupations which assist to clothe the world from the white cotton fields of Georgia. The black material of war has given away to the white staple of peace.

Of the extensive Confederate Powder Works nothing remains

except the obelisk enclosing the great Chimney. Its battlemented tower and lofty shaft, large proportions and beautiful workmanship, will bear evidence of the magnitude and style of their construction to future generations.

APPENDIX.

To the special duties of the manufacture of gunpowder were added the command of the Augusta Arsenal, on the 7th April, 1862, and at a later period that of the Military District of Augusta. In the early part of February, 1863, in connection with Captain Fairfax, of the Confederate Navy, the duties of getting into effective operation the extensive and unfinished Foundry Works constructed at Selma, Alabama, under contract with the War and Navy Departments, were superadded. When the communication with Richmond was endangered, in the latter part of the war, all the Arsenals south of Virginia, were committed to my charge.

It had been the design at an early period, of the Chief of Ordinance, to convert the Arsenal at Augusta into one of construction, and Capt. Gill was placed in charge with that object in view. On taking command, I found there were no existing facilities for large constructive works; thus the intention had to be for the time, abandoned, but it was found available, by the erection of several wood structures, for lighter work, such as the preparation of cartridges, fixed ammunition, signal rockets, fuses, primers, grenades, nitric acid, fulminates and percussion caps, etc.

It was necessary for works of construction to make available the water power of the canal within the city; accordingly, a Machine and Foundry establishment, then lying idle, was purchased. Air and cupola furnaces, etc., were added to the Foundry, and lathes, planers, drills, ets., were purchased from Holly Springs, Mississippi, and Columbus, Georgia, and from Selma, Alabama, and other places, and added to those already present in the Machine Works. Also an extensive and complete gun-carriage department was erected, and a powder-box manufactory established, together with several houses for the preparation of small arm catridges, and other purposes. These structures were rapidly erected, and machinists, founders, blacksmiths, tinners, harness makers, armorers, etc., and the various material required, were gathered from all available sources. The large brick building erected by Captain Gill at the Arsenal was converted into a harness and equipment department for field artillery; also used for tin and blacksmith shops, hospital and warehouse.

I was fortunate in obtaining skilled men for the heads of the several departments; among these were, at the Arsenal, Professor Wilson, Chemist; Master Armorer Oliver and F. Smyth; the last had charge of the Tinners' department, and also was Captain of the Operatives' Military company.

At the City Works were Foundry Superintendent Van Buren, of Clarksville; Superintendent Markey, of the Gun Carriage Department; Superintendent Walker, of the Machine Works. Mr. Wyman had charge of the Harness and Saddle and Equipment Department, but the artillery harness was mostly manufactured in the city, very satisfactorily, by Messrs. Jessup, Hatch and Day. There were several valuable foremen in the different shops, among them were Jaillet, Sharky, Shehan, Barr, and others, whose names are not recalled.

I was also materially assisted by Military Store-Keeper Girardey and several young officers—Captain Finney, and Lieutenants Waller, Collier, Sparrow, Hallam, and Cadet Lewis, and towards the close of operations by Captain Warren.

At the several works under my charge at Augusta, a large amount of war material was manufactured, in 1863, 1864 and part of 1865. The record of the last year has been lost. Among the various articles of the two above years were the following, copied from my official reports to the Chief of Ordinance:

110 Field Guns, mostly bronze, 12-pounder Napoleons. These guns were cast, turned, bored and finished complete at all points. Four of them now ornament the principal entrance to Washington's Headquarters, at Newburgh, New York.

174 Gun Carriages.
115 Caissons.
343 Limbers to Field Artillery.
21 Battery Wagons.
31 Traveling Forges.
10,535 Powder Boxes.
11,811 boxes for Small Arm Ammunition.
73,521 Horse Shoes.
12,630 Nitric Acid, pounds of.
2,227 ounces of Fulminate of Mercury.
2,455 Saddles, complete.
2,535 Artillery Harness, single sets of.
2,477 Signal Rockets.
85,800 rounds of Fixed Ammunition.
136,642 Artillery Cartridge Bags.
200,113 Time Fuses.
476,207 pounds of Artillery Projectiles.
4,580,000 Buckshot.
4,626,000 Lead Balls.
1,000,000 Percussion Caps.
10,760,000 Cartridges for Small Arms.

Together with an immense amount of Infantry, Artillery and Calvary equipments.

One hundred of the 12-pounder Napoleon guns were formed in-

to complete Batteries, and sent to the Army of Tenessee and North Georgia; the metal being received from Ducktown, Tennessee, and other places wherever it could be procured, including Church and other bells, and captured 6-pounder bronze cannon. The improved Hand-Grenades with General G. J. Raines' sensitive tubes were here manufactured, and many thousand sent to the Confederate armies.

The Army of Tennessee, before the fall of Atlanta, being at one period about to run short of small arm ammunition, and finding it impracticable to procure sufficient additional labor in time, a call was made on the ladies of Summerville and Augusta, to assist in making cartridges. This call was answered with all the promptness which their devotion to the cause inspired, and by their invaluable aid the danger was tided over by the production of 75,000 cartridges per day.

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